REMARKS

This paper is in response to the Office Action dated November 13, 2006. Applicants have amended the application as set forth above. Specifically, Claims 10-13, 15-17, and 25-28 have been canceled. No new matter is added by the amendments. Upon the entry of the amendments, Claims 1-3, 5-7, 9, and 21-24 are pending in this application. Applicants respectfully request the entry of the amendments and reconsideration of the application in view of the above amendments and the following remarks.

Rejection Under 35 U.S.C. § 102

The Examiner rejected Claims 10, 11, 16, and 17 under 35 U.S.C. § 102 (a) as being anticipated by Soininen et al. (U.S. Patent No. 6,482,740). Claims 10, 11, 16, and 17, however, have been canceled as set forth above, rendering the rejection of these claims moot.

Rejection Under 35 U.S.C. § 103

The Examiner rejected Claims 1, 6, and 7 under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. in combination with Toyoda et al. (U.S. Patent Application Publication No. 2001/0013617). Claims 2, 3, 5, and 9 were rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Soininen et al. and Toyoda et al. and further in view of Kim et al. (U.S. Patent No. 6,936,535) and Koh et al. (U.S. Patent No. 6,720,262). Claims 12, 13, and 15 were rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. in view of Kim et al. and Koh et al. Claims 21-24 were rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. in combination with Toyoda et al. and further in view of Gelatos et al. (U.S. Patent No. 5,391,517). In addition, Claims 25-28 were rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. in view of Gelatos et al.

Standard for Obviousness Rejection

The Patent and Trademark Office has the burden under section 103 to establish a *prima facie* case of obviousness. *In re Piasecki*, 745 F.2d 1468, 1471-72, 223 USPQ 785, 787-87 (Fed. Cir. 1984). To establish a *prima facie* case of obviousness, three basic criteria must be met: first,

there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings; second, there must be a reasonable expectation of success; and finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

Claims 1, 6, and 7

With respect to Claim 1, Applicants submit that the Office Action fails to establish a *prima facie* case of obviousness. Soininen et al. and Toyoda et al., individually or in combination, fail to teach or suggest all the limitations of Claim 1.

Claim 1 requires forming a ruthenium or rhenium (Ru/Re) barrier layer *on a surface of an insulation layer*, and forming a copper (Cu) layer on the Ru/Re barrier layer. Thus, no other barrier to copper diffusion is interposed between the Ru/Re barrier layer and the insulation layer. The prior art references do not teach or suggest Ru/Re usage as a barrier to Cu diffusion directly on the surface of the insulation layer. Soininen et al. only teaches or suggests Ru/Re usage as (i) a barrier to oxygen diffusion, (ii) an electrode, and (iii) a seed layer acting as a nucleation layer. Toyoda et al. only teaches or suggests Ru as *a secondary barrier*; importantly, Toyoda et al. teaches use of a primary intervening barrier layer (TaN) interposed between the Ru layer and an insulation layer.

a. Soininen et al.

Soininen et al. discloses a capacitor structure in its Background of Invention section. *See* Soininen et al., column 4, lines 1-24. The Background section discloses that high-k dielectrics, such as TiO_2 and Ta_2O_5, can be used as a dielectric material for a capacitor. *See id.* at column 4, lines 12-14. In addition, the reference states that inert metals, such as platinum group metals or *conductive metal oxides, such as RuO_2, must be used adjacent to the high-k metal oxides. See id.* at column 4, lines 14-19. In Soininen's Background section, it is also stated that conductive

metal oxides such as RuO_2 can be used to prevent high-k dielectrics from donating oxygen to a conductor. *See id.* at column 4, lines 12-24.

Soininen et al. discloses another capacitor structure in Figure 2. The capacitor structure consists of a contact plug 30, e.g., tungsten (W) or polysilicon, an insulator 32, an optional diffusion barrier 34, e.g., TiN, a lower electrode 36, e.g., Ru, Pt or RuO_2, a high-k dielectric film 38, e.g., barium strontium titanate (BST), and an upper electrode 40, e.g., Ru or Pt. *See id.* at column 5, lines 53-58; Figure 2 below.

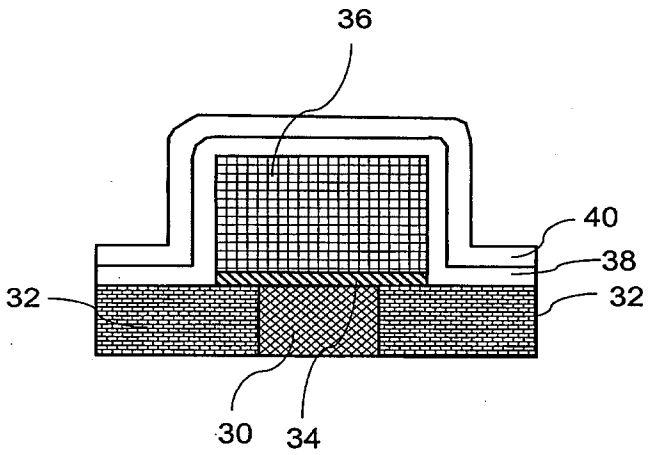


Fig. 2

Soininen et al. also discloses a dual damascene structure. *See id.* at Figure 1 below. The dual damascene structure consists of a metallization layer 2, e.g., Cu, an insulating layer 4, e.g., SiO_2, a via etch stop 6 made of, e.g., Si_3N_4, a via level insulator 8, e.g., SiO_2, a trench etch stop 10 made of, e.g., Si_3N_4, a trench level insulator 12, e.g., SiO_2, a diffusion barrier 14, e.g., TaN, a

seed layer 16 (e.g., metal oxides such as ReO_2 and RuO_2) and a via/trench fill metal 18, e.g., Cu. *See id.* at Figure 1; column 5, lines 46-52; column 6, lines 43-53; and column 7, lines 21-37.

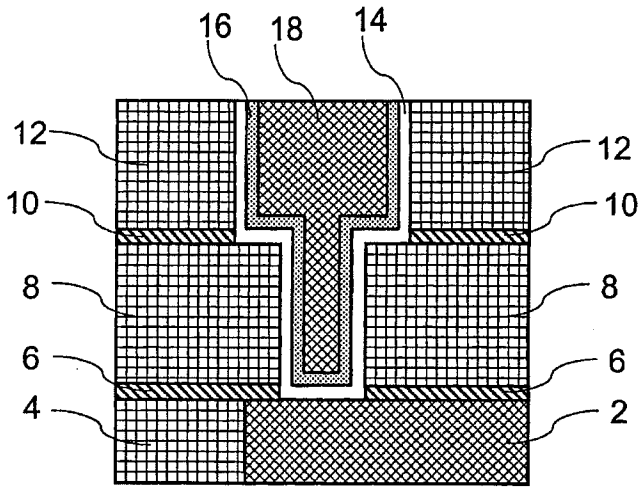


Fig. 1

b. Toyoda et al.

Toyoda et al. states in paragraph [0138] that "a ruthenium film (a second barrier layer) 37 having a uniform thickness of 50nm was formed on the surface of the wafer as shown in Figure 3E." Toyoda, paragraph [0138]; and Figure 3E. Toyoda et al. also discloses that ruthenium is known to be effective as a diffusion barrier (barrier film) against copper. *Id.* at paragraph [0138]. Toyoda et al. also discloses that the ruthenium film 37 is formed on a TaN (tantalum nitride) film

34 (a first barrier layer) while contacting copper wiring layers 35, 36. *See id.* at paragraph [0130] –[0138]; and Figure 3E below.

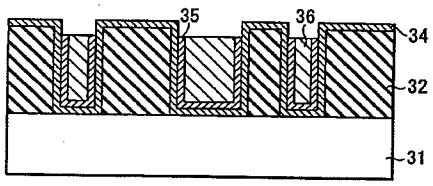


FIG. 3D

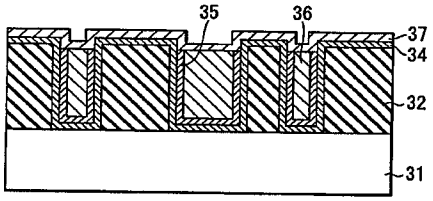


FIG. 3E

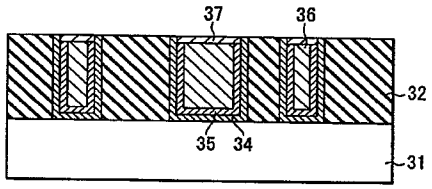


FIG. 3F

c. Claim 1 v. Soininen and Toyoda

Claim 1 of the present application is directed to a method for forming copper interconnection conductors for interconnecting integrated circuits on a substrate. Claim 1 recites "forming a barrier layer using ruthenium (Ru) or rhenium (Re) or their alloys *on a surface of an insulation layer* on said substrate..." In addition, Claim 1 recites "forming *a copper layer on said barrier layer* ..."

Soininen et al., however, fails to disclose "forming *a barrier layer using Ru or Re on a surface of an insulation layer.*" In the capacitor structure disclosed in the Background section

and Figure 2 of Soininen et al., although Ru or RuO_2 is used adjacent to an insulation layer, it is *not* used as a barrier against copper diffusion. In addition, in Figure 1 of Soininen et al., Ru or Re is only used as a seed layer for electroplating.

In Soininen's Background section, it is stated that conductive metal oxides such as RuO_2 can be used to prevent high-k dielectrics from donating oxygen to a conductor. *See* Soininen et al., column 4, lines 12-24. Thus, RuO_2 is not taught or suggested to serve as a barrier against copper diffusion.

With respect to Figure 2 of Soininen et al., Ru or RuO_2 is used only as an electrode material, but not as a barrier material against copper diffusion. First, the upper electrode 40 is formed of Ru, Pt or RuO_2 on the high-k dielectric film 38 (an insulating layer). The upper electrode 40, however, only serves as an electrode of the capacitor, but not as a barrier to copper diffusion, because there is no copper in the capacitor structure of Figure 2 of Soininen et al. *See id.* Similarly, the lower electrode 36 is formed of Ru or Pt. *See id.* The lower electrode 36 does not serve as a barrier to copper diffusion because there is no copper in the capacitor structure. *See id.* In addition, the usage of Ru as an electrode material is further supported by a separate diffusion barrier layer 34 formed of, e.g., TiN. *See id.* Therefore, Ru or RuO_2 is not taught or suggested to serve as a barrier against copper diffusion.

Soininen et al. discloses another embodiment where a ruthenium or rhenium oxide layer is used. *See id.* at Figure 1; and column 5, lines 46-52. This embodiment discloses a seed layer 16 formed of metal oxide such as RuO_2 or ReO_2. *See id.* at Figure 1; column 5, lines 46-52; column 6, lines 43-53; and column 7, lines 21-37. However, it is stated that the seed layer 16 acts as a nucleation layer for a CVD process. *See id.* at column 3, lines 28-29. In addition, the seed layer 16 is formed on the diffusion barrier layer (TaN), but <u>not</u> directly on the surfaces of the insulators 4, 8, 12, as shown in Figure 1 of Soininen et al. *See id.*

Toyoda et al. does not cure this deficiency because it also fails to disclose "forming *a barrier layer using Ru or Re on a surface of an insulation layer,*" as recited in Claim 1. The structure shown in Figure 3E of Toyoda et al. does not have a ruthenium layer formed directly on a surface of an insulator. *See* Toyoda et al., Figure 3E; and paragraph [0138]. Like the damascene embodiment of Soininen et al., Toyoda et al. only discloses a ruthenium layer 37 formed on a surface of a conductive layer 34 (a first barrier layer), <u>not</u> on a surface of the

underlying insulation layer. *See id.* In addition, the reference explicitly states that the ruthenium layer serves as a *second barrier layer.*

As set forth above, Soininen et al. and Toyoda et al., either individually or in combination, fail to teach or suggest all the limitations of Claim 1. Thus, the Office Action fails to establish a *prima facie* case of obviousness. Therefore, Claim 1 is allowable under 35 U.S.C. 103(a) over Soininen et al. in combination with Toyoda et al. Claims 6 and 7 depend directly or indirectly from Claim 1, and are allowable for substantially the same reasons as explained above.

Claims 2, 3, 5, and 9

With respect to Claims 2, 3, 5, and 9, Applicants submit that the Office Action fails to establish a *prima facie* case of obviousness. Soininen et al., Toyoda et al., Kim et al., and Koh et al., either alone or in combination, do not teach or suggest all the limitations of the claims.

Claims 2, 3, 5, and 9 depend directly from Claim 1. As set forth above, Soininen et al. and Toyoda et al., either individually or in combination, fail to teach or suggest all the limitations of Claim 1. Kim et al. and Koh et al., either individually or in combination, fail to cure this deficiency. Neither of these two references teaches or suggests "forming a barrier layer using Ru or Re *on a surface of an insulation layer,*" as recited in Claim 1. Therefore, Claims 2, 3, 5, and 9 are allowable under 35 U.S.C. 103(a) over Soininen et al. and Toyoda et al. and further in view of Kim et al. and Koh et al.

Claims 12, 13, 15, and 25-28

Claims 12, 13, 15, and 25-28 have been canceled as set forth above, rendering the rejection of these claims moot.

Claims 21-24

With respect to Claims 21-24, Applicants submit that the Office Action fails to establish a *prima facie* case of obviousness. Soininen et al., Toyoda et al., and Gelatos et al., either alone or in combination, do not teach or suggest all the limitations of the claims.

Claims 21-24 depend directly or indirectly from Claim 1. As set forth above, Soininen et al. and Toyoda et al., either alone or in combination, fail to teach or suggest all the limitations of

Claim 1. Gelatos et al. does not cure this deficiency because it fails to disclose "forming a barrier layer using Ru or Re *on a surface of an insulation layer,*" as recited in Claim 1. Therefore, Claims 21-24 are allowable under 35 U.S.C. 103(a) over Soininen et al. in combination with Toyoda et al. and further in view of Gelatos et al.

For all of these reasons, Applicants respectfully request withdrawal of this rejection, and allowance of the pending claims.

CONCLUSION

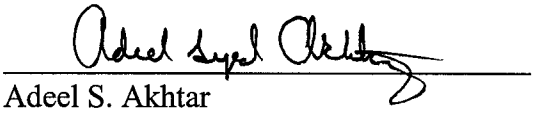
In view of Applicants' amendments to the claims and the foregoing remarks, Applicants respectfully submit that the present application is in condition for allowance. Should the Examiner have any remaining concerns, which might prevent the prompt allowance of the application, the Examiner is respectfully invited to contact the undersigned at the telephone number appearing below.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: January 10, 2007

By: 

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